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ABSTRACT

This study examined attitude variables in relation to kindergarten mathematics. The following research questions were addressed: (1) Will kindergarten children who are taught number concepts using a curriculum based on a numeration learning hierarchy have a significantly more positive attitude towards mathematics than pupils taught number concepts using curriculum not based on this hierarchy; (2) What factors underlie the attitudes toward mathematics in kindergarten children; and (3) Can the attitudes towards mathematics of kindergarten children be measured? An experimental posttest-only design was used. The experimental study involved four instructional weeks using the numeration learning hierarchy curriculum, "Fundamentals Underlying Number," by Wilson and Uprichard. Because no assessment instrument was available, the Kindergarten Mathematics Attitude Instrument (KMAI) was developed. Results indicated significant differences between the attitudes of the experimental and control group. Major conclusions were: (1) It is possible to reliably measure the mathematics attitude of young children using KMAI; (2) Two factors, fear of mathematics and self-affirmation, resulted from data analysis, further substantiating the validity and reliability of the findings; and (3) Kindergarten children taught number concepts using a numeration learning hierarchy curriculum have a significantly more positive attitude towards mathematics than pupils not taught in this manner. (MP)

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THE EFFECT OF A NUMERATION LEARNING HIERARCHY ON MATHEMATIC ATTITUDES IN KINDERGARTEN CHILDREN

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Statement of the Problem

Positive attitudes toward mathematics in the early years are crucial to children's learning and progress in school. Little attention has been paid to the measurement of these attitudes in very young children despite the evidence that attitude toward mathematics in adulthood can be traced to childhood (Morrisett & Vinsonholer, 1965) and may be formed as early as third grade (Fedon, 1958; Stright, 1960).

In discussing human characteristics and learning, Benjamin Bloom (1976) suggests that subject-related attitudes vary, are formed early in children, and are resistant to change. The results of comparative studies from 1967 to 1975 by the International Association for the Evaluation of Educational Achievement all suggest that attitudes of primary-age children toward mathematics are not as positive as attitudes toward reading. Empirical data detailing how mathematics programs may influence mathematics attitudes in young students is scarce (Aiken, 1976; Bloom, 1976; Gagne, 1973; Neale, 1970). The lack of research on mathematical attitudes of young children may be due in part to the absence of a reliable attitude instrument for children who have not yet learned to read.

Educators in the field of mathematics strongly agree that the essence of mathematics is not a set of observable skills to be learned

by rote (Ashlock, 1978, 1972; Wilson, 1976; Johnson & Wilson, 1976; Payne, 1976; Lovell, 1971). These researchers also assert that mathematics is not verbalization without comprehension of number concepts nor is it the unthinking paper and pencil manipulation of symbols. Such behaviors, useful as they are, are only the visible evidence of the mathematical concepts underlying them.

Spodek (1978) and other early childhood educators (Schickedanz, York, Stewart & White, 1977; Kamii & Devries, 1976; Lavatelli, 1973), continually stress the significance of conceptual development in early mathematics curricula. These researchers indicate that the primary objectives of an early childhood mathematics curriculum should be the fundamental concepts of mathematics. This conceptual approach to early mathematics builds upon young children's curiosity as they interact with their environment and progress in a sequential continuum of learning hierarchies. Bloom (1976) asserts that from a behavioral perspective such as that of Gagne, (1977, 1965), the internalization of a cognitive learning hierarchy, may of itself, influence affective outcomes in any given learning sequence of events. Consequently, an appropriate early childhood mathematics curriculum must have characteristics of conceptual development through physical interaction with manipulatives, as espoused by Piaget (1965), and hierarchical structure as an instructional mode which could relate to affective attitudes toward mathematics in students. In this mathematics setting, it is believed that success in early childhood mathematics can give young learners a sense of competence, self-esteem and autonomy based on reason. This study attempted to measure indicators of these affective

variables in early childhood mathematics.

Three research questions were presented:

1. Will kindergarten children who are taught number concepts using a curriculum based on a numeration learning hierarchy have a significantly more positive attitude towards mathematics than kindergarten children who are taught number concepts using curriculum which is not based on a numeration learning hierarchy?

2. What factors underlie the attitudes toward mathematics in kindergarten children?

3. Can the attitudes towards mathematics of kindergarten children be measured reliably?

The following hypothesis was posited:

> Mean mathematics attitude scores will be significantly different in kindergarten students receiving instruction with curriculum based on numeration learning hierarchy, than the mean mathematics attitude scores of students not receiving instruction in a curriculum based on a numeration learning hierarchy.

Theoretical Framework

Attitudes, according to Gagne (1977), are outcomes of learning which result in internal states that influences individual selection and choice. Triandis (1971) points out three different aspects of attitudes: (1) cognitive, pertaining to the ideas or prepositions that express the relation between situations and attitudinal objects; (2) affective, pertaining to the emotion or feeling that accompanies the idea; and (3) behavioral, pertaining to the predisposition or readiness for action. Field theorist and perceptual psychologists have long been concerned with links between these aspects and an individual's perception and behavior. Combs and Snygg (1959) suggest that as a basic axiom, an individual's behavior is completely determined by his/her

perceptual field. Thus, the way an individual thinks, feels, and functions, reflects that individual's awareness, understanding, or perception of him/herself and the situation.

Generally speaking, these factors are considered to characterize the internal states that influence learning and attitudes. Every attitude state has an affective/emotional component, a cognitive/intellectual component, and a behavioral/action-tendency component (Hovland, 1960, 1953, 1949). Differences among theories of attitude pertain to questions of which component is the most influential regarding attitudes. There is evidence to support each of these components related to attitude state and even more theoretical views that attempt to further define the complexity and diversity of attitudes in individuals.

In regard to subject-related attitudes, the National Science Foundation (1977) stresses the importance of a positive self-image in students as related to perception, performance, and expectations in mathematics. Self-concept and achievement in mathematics were found to significantly relate in numerous studies by Moore (1972), Messer (1972), Koch (1972), Bachman (1969), Stillwell (1969), and Hayes (1968). Moore (1972) noted that while it may be concluded that the self-concept and attitudes toward mathematics influence achievement in mathematics, it is also reasonable to infer a reciprocal cause-effect relationship between these variables.

When attitude scores are used as predictors of achievement in mathematics, a low but significant positive correlation is usually found (Neale, 1969). This is true at the elementary level (Crosswhite,

1972; Callahan, 1971; Burbank, 1970), undergraduate level (Fenneman, 1974; Wilson, 1973; Edwards, 1972), and postgraduate level (Webb, 1972). It is also shown to be true of students in other countries (Kulkarni, 1970) and minority groups in the United States (Jackson, 1974). An occasional study (Webb, 1972) finds that attitude is the most important predictor of success in mathematics, but usually it is secondary to ability as a forecaster of achievement.

At the elementary and junior-high levels, attitude toward mathematics and achievement in the subject are shown to be significantly related to a number of personality variables indicative of adjustment (Naylor & Gaudry, 1973; Neufield, 1968; Swafford, 1970). Although some studies have failed to find significant sex differences (Jacobs, 1974; Merkel, 1974; McClure, 1971), differences in both attitudes and achievement in mathematics are frequently found to favor boys over girls from elementary school and beyond (Hilton & Berglund, 1974; Simpson, 1974; Keeves, 1973; Neven, 1973). It has been reported that mathematics test anxiety is appreciably higher for girls than boys (Szetela, 1973). Greater interest and more positive attitudes toward mathematics and science on the part of males have been found in other countries as well as the United States (Keeves, 1973; Nevin, 1973).

A major issue in examining student attitudes toward mathematics has been the quality of measurement (Sandman, 1974; Knapp, 1973; Fellows, 1973; Mastantuono, 1972). Likert-type scales (Aiken, 1974; Hunkler, 1972) and semantic differential (McCallon & Brown, 1972; Kane, 1968) instruments have been most widely used in assessing affective variables of attitudes toward mathematics. Although various instruments

are discussed in the literature, the Revised Dreger-Aiken Scale of Mathematics Attitude, which is scored on two scales, enjoyment of mathematics and fear of mathematics, is widely used (Creswell, 1974). Factor analysis of these scales have accounted for 62 percent of total variance. Later studies by Silverman (1974, 1978) and Parrish (1978) found three dimensions of attitude based on the Revised Dreger-Aiken instrument: enjoyment of mathematics, apprehension of ability, and fear of mathematics. Because of high reliability and validity score studies using the Revised Dreger-Aiken instrument, it was utilized in the development of the instrument for this study.

Methods and Procedures

The basic method of research utilized in the study was an experimental posttest-only design. Experimental variations were controlled through sampling and randomization procedures involving kindergarten teachers and students (Tuckman, 1978; Dayton, 1970; Campbell & Stanley, 1963). An instrument was developed and tested in a pilot study involving 75 kindergarten students. The research study involved four instructional weeks for kindergarten students using the Fundamentals Underlying Number (Wilson & Uprichard, 1972) numeration learning hierarchy curriculum previously validated.

Sample

The kindergarten teachers and students participating in the research study were drawn from a suburban school district in the Southwest United States. Twelve kindergarten teachers in four schools were

randomly assigned to six morning and six afternoon treatment groups, and six morning and six afternoon control groups. From an initial pool of 404 students, a final sample of 120 experimental and 120 control students were randomly selected.

Instrument

The Kindergarten Mathematics Attitude Instrument (KMAI) was developed as the instrument which assessed the effect of the specific kindergarten numeration hierarchy curriculum on affective variables in this study. The KMAI was synthesized from two other attitude instruments. The content was based on the Revised Aiken-Dreger Attitude Toward Mathematics Scale (Aiken & Dreger, 1961) and the response modality was based on the Student Evaluation of Teachers Instrument (Hoak, Kleiber, & Peck, 1972). (see Appendix A) The original and revised Aiken-Dreger Attitude Toward Mathematics Scale established the content validity which was drawn upon in the use and adaptation of the KMAI instrument for the pilot (see Appendix B) and research study (see Appendix C). The constructs had been assessed repeatedly in other studies (Silverman, 1976, 1978; Creswell, 1974; Parrish, 1972) to produce both two-factors (enjoyment and fear of mathematics) and three-factors (enjoyment, apprehension of ability, and fear of mathematics). Items were built to assess constructs already shown to account for 65 percent of the variance on scales in these earlier studies.

The instrument items on the KMAI incorporated actual terminology whenever possible (e.g. happy, afraid) and consistency of words. The KMAI modified the language of the Revised Aiken-Dreger by using

appropriate words for kindergarten children (e.g., number was used rather than mathematics). Eight items were written for each of the three factors in the pilot, making a total of 24 items. The pilot study established the reliability (r = .94) of the final research instrument with the two factors of self-affirmation and fear.

The KMAI was individually administered by trained mathematics education doctoral students. Directions were adapted from the Administration Manual of the Student Evaluation of Teachers Instrument, designed for use with kindergarten children. Each of the declarative sentences from the KMAI was printed on a small card and read to a child. If the message card about numberwork and numbertime was true for the children, they mailed the card in the "mailbox"; but if the message was not true for them, they put the card in the "trashcan". (see Appendix A) This response modality as observed in the testing situation indicated that the children understood the items and were responding reliably.

Control Group

Control teachers had no formal, mandated approach to kindergarten mathematics. Each had broad instructional freedom and decision power regarding use of materials and time on task. With the exception of two control teachers, all control teachers were quite similar and consistent in what they were doing with kindergarten mathematics. Control teachers used various pages from commercial workbooks and ditto sheets for semi-directed instruction with groups of five to eight students. Emphasis was generally on numerals, counting, and number sets within

the instructional lesson. During these 15 to 20 minute daily experiences, teachers frequently used an available chalkboard for illustration. Visual materials included various flash cards of object sets and numerals, as well as felt boards.

Two of the control teachers had their students participating in a small group rotation involving the use of cuisenaire rods which were manipulated by students in structured lessons organized for small groups. Simple activity sheets had been planned to use in connection with the cuisenaire rods. These activities were teacher-guided.

Other mathematics material and manipulatives were present in control classrooms. These materials were in a designated area of the kindergarten room and available to students during center time. (see Appendix D) Although not widely observed during the researchers site visits, it was assumed that all of these manipulatives were available for student use during center choices. None of the manipulatives or materials were arranged in any systematic order for the mathematics program. The control teachers had several sessions with the researcher to discuss their role in the study.

Experimental Group

All experimental classes received instruction with the specified curricula, Fundamentals Underlying Number (Wilson & Uprichard, 1972), for 15 minutes per day (75 minutes per week) for a period of four weeks in small group settings (4-6 students). Trained treatment teachers immediately noticed that a strong feature of the F.U.N. program was that the lessons were all game formats--intended to be fun,

easy to play, non-competitive and to involve students actively throughout. Game formats sought to sustain the child's curiosity and motivation and to encourage maximum independence through a self-checking process whereby the child determined for him/herself whether a response was correct. Most importantly, each game was designed to provide one small step in a carefully structured continuum of learning experiences, experiences whereby the child physically manipulates objects to reconstruct the mathematics number concept being stressed in a specific game.

The hierarchical order in which these number concepts were implemented in the experimental classes was: (1) one-to-one correspondence and properties; (2) greater than, less than, and properties; (3) equivalence class and order. These same three major concepts were developed at progressively higher levels through two basic games: Find It (the child identified an example of the concept) and Make It (the child constructed an example of the concept).

The levels reflected increasing complexity in two respects. First, the games moved gradually from concrete examples of the concept (such as a set of blocks) to symbolic (such as a counting set, the words one, two, three, etc.) Second, the number and degree of differences among examples of the concept increased. For instance, at early levels, the child compared concrete sets arranged in identical patterns; at higher levels, students compared sets arranged in varied patterns. (see Appendix E) Later, students even compared a visual set of blocks with an auditory set of sounds. A sequential flow chart

of the game levels and corresponding concept development was used by experimental teachers for record keeping and documentation with audio tapes. (see Appendix F) All games used the same basic set of materials in varying combinations and difficulties. (see Appendix G) Teacher's plans were available in narration form or outline form. (see Appendix H)

Crucial to the steps in every game was the child's self-confirming process. In the self-confirming process, kindergarten children used three distinct steps: (1) Set A--the holes in the child's board; (2) Set B--the holes in the sample set boards on the spinner cloth; and (3) Set C--the movable blocks. In this way, a child was led to see that her/his number board was equivalent to her/his set of blocks and blocks could be moved to a sample set board on spinner cloth.

All experimental teachers varied the pace. At the end of the four week treatment period, groups within the experimental classes were at different levels on the hierarchy.

Analysis of Data

Instrument Reliability

For the total posttest sample of 240 kindergarten subjects from this study, the mean scores and standard deviations on Self Affirmation of Mathematics (SA) and on Fear of Mathematics (F), of the Kindergarten Mathematic Attitude Instrument (KMAI), were commensurate to pilot mean scores and standard deviations as shown in Table 1.

Table 1

Means and Standard Deviations for Self Affirmation and Fear Scales

	Pilot Study N = 75		Final Study N = 240	
Scale*	$\bar{X}$	SD	$\bar{X}$	SD
Self Affirmation	10.51	5.39	11.54	4.59
Fear	6.44	2.30	5.66	3.02

*Maximum Score: SA = 15: F = 8

Cronbach Alpha was computed for each of the scales yielding reliability coefficients of r = .94 and .94 respectively. These reliability coefficients slightly improved those found in the pilot of r = .94 and .87.

Corrected item-total correlation or the correlation of the items with the score derived from the remaining scale items, ranged from .46 to .82 for Self Affirmation. With the exception of item 17 on the Fear scale, the range of corrected item-total correlation fell between positive .79 and .85. Item 17 was lower at .45 (see Appendix I).

Final analysis of the Kindergarten Mathematic Attitude Instrument indicated that the two scales were positively correlated as shown in Table 2. The correlation of .67 between the two scales was sufficient to merit treating the scales as multiple analysis of variance (MANOVA).

Table 2

Correlation Matrix for Two Scales

	Self Affirmation	Fear
Self Affirmation	1.0	
Fear	.67	1.0

It should be recalled that a high score on either scale was an indicator of a positive attitude direction. Therefore, a high Self Affirmation score correlated to a high Fear score. These data provide evidence for answering the two subsumed research questions in the affirmative. It is possible to reliably measure the attitude toward mathematics of kindergarten children. The factors which appear to underlie this attitude are Self Affirmation of Mathematics and Fear of Mathematics.

Multivariate Analysis

The null hypothesis that there would be no significant difference between experimental and control groups on the two dependent variables of Self Affirmation of Mathematics and Fear of Mathematics, was examined. The MANOVA indicated an overall significant difference between the experiemental group and control group, by a multivariate F with 2 and 237 degrees of freedom, equal to 55.10 ($F_{2,237} = 55.10$; $p < .0001$). The null hypothesis was thus rejected at the postulated level of significance of $p < .05$. These data provide an affirmative answer to the major research question as stated previously in this study.

Kindergarten children who are taught number concepts using a curriculum based on a numeration learning hierarchy have a significantly more positive attitude towards mathematics than kindergarten children who are taught number concepts using curriculum not based on a numeration learning hierarchy. Related statistical data are shown in Table 3.

Table 3

Descriptive Statistics for Groups

	Experimental Group N = 120		Control Group N = 120	
	$\bar{X}$	SD	$\bar{X}$	SD
Variable*				
Self Affirmation	13.88	2.10	9.20	5.18
Fear	7.23	1.54	4.09	3.32

*Maximum Score: SA = 15; F = 8

Since the experimental group was significantly distinguished from the control group on these two variables of attitude, further analysis was undertaken to determine which attitude scale contributed to this significant difference. Using Stevens technique (1972), a post hoc discriminate analysis was conducted. See Table 4. The discriminate function weights from the discriminate analyses were transformed into reliability coefficients which, when squared, indicated the amount of variance each factor accounted for in distinguishing the groups (Porebski, 1966).

Table 4

Discriminant Function Coefficients for Two Scales of KMAI

Scale	Raw Coefficient	Standarized Coefficient
Self Affirmation	.136840	.5413
Fear	.228647	.5924

Table 5 presents the reliability coefficients and the percentage of variance accounted for by each factor in distinguishing between the groups. As indicated in Table 5, both factors were contributors to

Table 5

Reliability Coefficients and Percentages of Variances Accounted for by Two Scales

Scale	Reliability Coefficient	Percent Variance
Self Affirmation	.171	11%
Fear	.285	14%

determining differences between the experimental and control groups. Both factors were arrayed positively on the function. Essentially, Fear of Mathematics contributed three percent more than Self Affirmation to determining the total variance of 25 percent that can be accounted for by these two variables.

Final post hoc analysis addressed the multivariate null hypothesis that there would be no significant difference in experimental and

control groups due to morning or afternoon attendance ($F_{2,235} = 1.36$; $p < .2583$). Additionally, no significant difference was found due to treatment x time interaction, ($F_{2,235} = 1.37$; $p < .2569$). Thus, these results do not support the teacher speculation that the treatment worked differently with morning and afternoon students.

Descriptive Analysis

Further analysis employed descriptive statistics to summarize information on differences among experimental teachers and control teachers. Table 6 shows the mean and standard deviation of experimental teachers and control teachers relative to Self Affirmation of Mathematics. The significant difference between experimental and control groups set forth in the MANOVA test of hypothesis is further substantiated as the highest control group score is three points lower than the lowest experimental groups score. There was no overlapping of scores between experimental groups and control groups. There was also greater variability in the control group. This also supported the idea that teachers in the experimental group were functioning similarly within experimental group conditions.

Table 6

Teachers Descriptive Statistics for Self Affirmation*

	Number of Students	Teachers	$\bar{X}$	SD
Exper.	20	1	13.0	2.69
	20	2	13.55	2.85
	20	3	13.95	1.60
	20	4	14.0	2.18
	20	5	14.10	1.68
	20	6	14.65	.75
N =	120			
Control	20	7	6.90	4.64
	20	8	9.37	4.89
	20	9	10.44	5.59
	20	10	9.90	5.29
	20	11	10.00	5.57
	20	12	8.80	5.08
N =	120			

*Maximum Score = 15

Table 7 shows the mean and standard deviation of experimental teachers and control teachers relative to Fear of Mathematics. Again, the significant difference of the MANOVA test of hypothesis is further substantiated as the highest control group score is almost two points lower than the lowest experimental group score. No overlapping of scores existed between experimental groups and control groups, as was also noted regarding Self Affirmation of Mathematics.

Table 7

Teachers Descriptive Statistics for Fear*

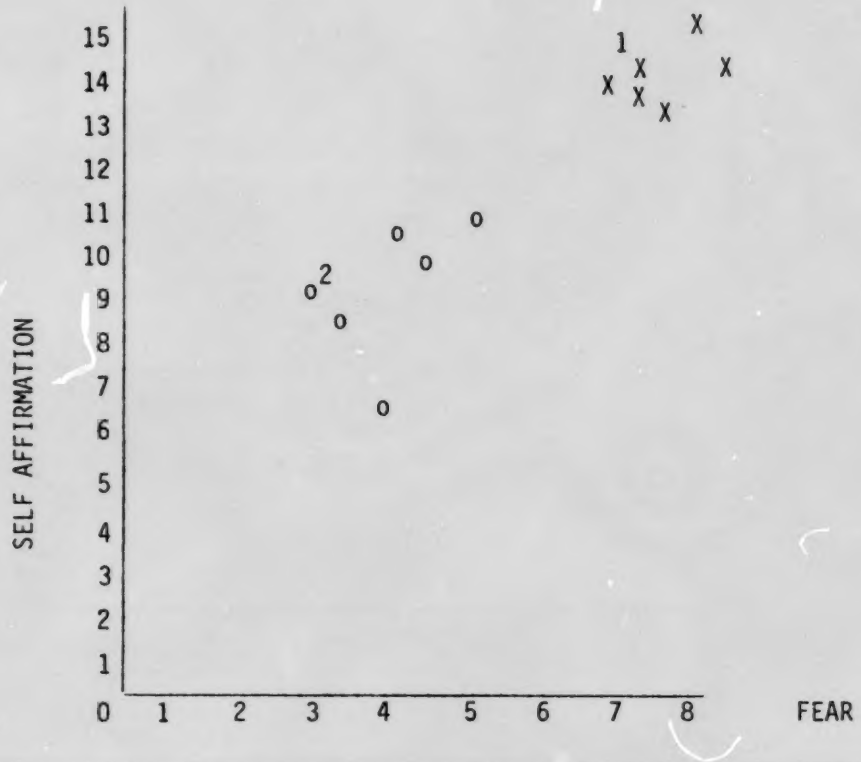
	Number of Students	Teachers	$\bar{X}$	SD
Exper.	20	1	7.20	1.47
	20	2	7.0	1.56
	20	3	6.95	1.99
	20	4	7.05	2.01
	20	5	7.70	.57
	20	6	7.50	1.24
N = 120				
Control	20	7	3.75	3.48
	20	8	3.33	3.23
	20	9	5.12	3.26
	20	10	4.65	3.39
	20	11	4.45	3.20
	20	12	3.60	3.44
N = 120				

* Maximum Score = 8

Table 8 shows a graph of the centroid for each teacher of their means for Self Affirmation of Mathematics and Fear of Mathematics. The lower variability can be seen for the experimental group as opposed to the control group. The distinction between the two groups is evident.

Table 8

Graph of Centroid for Each Teacher's Mean Score on Two Scales



[1] x = experimental [2] x = control

A final descriptive analysis examined the responses of experimental and control groups on the Kindergarten Mathematic Attitude Instrument. Absolute frequencies and adjusted frequencies were used to summarize findings. Response items for Self Affirmation are shown in Table 9 with positive/negative responses indicating an attitude direction.

Table 9

Self Affirmation Item Frequency and Adjusted Frequency of Group Responses

	Absolute Frequency				Adjusted Frequency (%)			
	Expr.		Con.		Expr.		Con.	
Items	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)
1	114	6	77	43	95.0	5.0	64.2	35.8
2	104	16	75	45	86.7	13.3	62.5	37.5
4	110	10	54	66	91.7	8.3	45.0	55.0
5	113	7	75	45	94.2	5.8	62.5	37.5
7	115	5	64	56	95.8	4.2	53.3	46.7
8	107	13	82	38	89.2	10.8	68.3	31.7
10	103	17	89	31	85.8	14.2	74.2	25.8
11	111	9	74	46	92.5	7.5	61.7	38.3
13	110	10	79	41	91.7	8.3	65.8	34.2
15	114	6	58	62	95.0	5.0	48.3	51.7
16	106	14	87	33	88.3	11.7	72.5	27.5
18	115	5	76	44	95.8	4.2	63.3	36.7
19	115	5	79	41	95.8	4.2	65.8	34.2
21	114	6	59	61	95.0	5.0	49.2	50.8
22	114	6	76	44	95.0	5.0	63.3	36.7

N: Experimental = 120
Control = 120

Generally speaking, all experimental group responses were highly positive. Control groups were more divided in responding to the Self Affirmation items.

Table 10 presents the response items for Fear of Mathematics in experimental and control groups. Yes responses should not be interpreted as positive responses to the presence of fear of Mathematics, rather a positive yes indicates no fear and a negative no indicates fear.

Table 10

Fear Item Frequency and Adjusted Frequency of Group Responses

	Absolute Frequency				Adjusted Frequency (%)			
	Expr.		Con.		Expr.		Con.	
Items	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)
3	109	11	59	61	90.8	9.2	49.2	50.8
6	111	9	58	62	92.5	7.5	48.3	51.7
9	106	14	59	61	88.3	11.7	49.2	50.8
12	113	7	64	56	94.2	5.8	53.3	46.7
14	108	12	56	64	90.0	10.0	46.7	53.3
17	105	15	76	44	87.5	12.5	63.3	36.7
20	109	11	61	59	90.8	9.2	50.8	49.2
23	107	13	58	62	89.2	10.3	48.3	51.7

N: Experimental = 120
Control = 120

Final analysis on the Fear of Mathematics items showed that experimental group responses were highly positive. Control group was again split, in fact, quite evenly in positive and negative responses for the fear items. This finding was consistent with that shown regarding Self Affirmation of Mathematics. The response patterns obviously contributed to significant findings in this study.

Discussion

The major research focus of this study was the question of whether kindergarten children who are taught number concepts using a curriculum based on a numeration learning hierarchy have a significantly more positive attitude towards mathematics than kindergarten children who are taught number concepts using curriculum not based on a numeration learning hierarchy. Inherent to this major focus were two other questions:

(1) Can the attitudes toward mathematics of kindergarten children be measured reliably?

(2) What are the factors which underlie the attitudes towards mathematics in kindergarten children?

A pilot study was undertaken which focused on the development of a reliable instrument ($r = .94$ and $.87$). This entailed the development and use of scales with which the research dependent variables, self affirmation of mathematics and fear of mathematics, were measured. The study then assessed these dependent variables in the experimental use of the curriculum based on a numeration learning hierarchy as an instructional mode for kindergarten children.

The research hypothesis, that the mean mathematics attitude scores will be significantly different in kindergarten students receiving instruction with curriculum based on a numeration learning hierarchy, than the mean mathematics attitude scores of students not receiving instruction in a curriculum based on a numeration learning hierarchy was supported. The MANOVA test of hypothesis indicated an overall

significant difference between the experimental group and control group, by a multivariate F with 2 and 237 degrees of freedom, equal to 55.10 ($F_{2,237} = 55.10$; $p < .0001$).

Treatment Results

The results of the study indicated that the attitudes of experimental treatment group were significantly different from the control group. There was in fact, a magnitude of difference measured between the two groups. The experimental score means on both self affirmation of mathematics and fear of mathematics were significantly more positive than control score means. One can conclude that kindergarten participation in this particular numeration learning hierarchy curriculum was the determiner of positive kindergarten attitudes toward mathematics.

The most obvious difference between the experimental and control group experiences in learning number concepts during the four weeks of this study was the self-confirming aspect of the experimental curriculum and the sequential nature of the curriculum. These two factors permit the student to move through the curriculum at a pace which is determined by the child's conceptual development. In the control group, teachers determined the pace, and answers were teacher-confirmed rather than student-confirmed. In fact, the student-pacing of the curriculum was apparent from the evidence that the experimental teachers moved through the curriculum at different rates, not all ending the four weeks at the same point on the hierarchy.

The students of the two teachers who adjusted the pacing by moving through the curriculum more quickly in response to their children's behaviors had the highest mean scores on both parts of the attitude scale, self affirmation of mathematics and fear of mathematics. This lends support to the contention that the self-confirmation and student-determined pacing of the curriculum may be key factors which explain the significant difference found in favor of the experimental group.

The high percentage (90%) of positive responses to test items from experimental subjects, indicated significantly greater confidence in their ability, greater satisfaction in mathematics, and less fear of mathematics, than did the positive responses from control subjects (45% to 65%). This finding seems to substantiate findings by Naylor and Gaundry (1973) and other researchers, indicating that students with more positive attitudes toward mathematics view themselves as more self-confident and persevering, and have a higher sense of self-esteem. Certainly, the findings of this study indicate that a curriculum based on student-confirmation and student-determined pacing of a hierarchy of concepts results in more positive attitudes towards mathematics.

Several rival hypotheses or alternate explanations for the results of this study could be offered. On the one hand, students were expected to generate more positive attitudes by the experimental teachers and their own attitudes might have influenced student attitudes toward mathematics. This possibility is not adequately supported in research findings to make it likely (Van DeWalle, 1973; Caezza, 1970;

Wess, 1970). In fact, the findings of Phillips (1973) and Starkey (1971) would refute the possibility of teacher expectancy happening in all experimental classes. Their findings indicate that the effect of teacher attitudes and behavior on student attitudes varies greatly from teacher to teacher. Rosenbloom and others (1966) minimize teacher expectancy in the finding that teaching effectiveness contributed significantly to the attitude and perceptions of pupils concerning their teachers and their methods, curriculum, or class as a group.

On the other hand, even if teacher expectancy had transpired, it is not likely that it could have influenced all experimental groups. The results would show a wider range of variance among experimental teacher mean scores. But the findings reflect a relatively narrow range of mean classroom scores on Self Affirmation of Mathematics and on Fear of Mathematics among experimental teachers. These findings support the similarity of functioning among experimental teachers in this study and could not be considered likely to have occurred because of teacher expectancy.

An additional concern might be the novelty of the treatment conditions. Novelty could be viewed in two perspectives: (1) novelty of the materials or (2) novelty of the game experiences provided by the curriculum. Both types of novelty existed in experimental treatment, since the patterned number boards and specific game format were not used before by any of the teachers. However, other treatment materials were not novel to experimental students. Unifix cubes, table blocks, beads were used as manipulatives by all kindergarten students prior to

and during the treatment period. None of these items or the use of manipulatives in general was novel to either experimental or control group. Assorted games were also present in both groups, so gaming per say could not be considered a novel experience either. Therefore, novelty of the treatment conditions cannot be considered a viable rival hypothesis which could account for the significant difference found in this study.

The significant difference found for the experimental group might be accounted for solely by the increased use of manipulatives by this group. It can be noted that the two teachers in the control group at school B, who used cuisenaire rods, had student mean scores on both attitude scales which were among the three highest scores for the control teachers. Yet these mean scores and others in the control groups were lower than any experimental mean score.

Therefore, based on the discussion of treatment considerations in this study, the following conclusion is supported. A curriculum based on a hierarchy of numeration concepts which emphasizes student confirmation of responses, and where the rate of progressing through the curriculum is determined by students number concept development results in more positive attitudes towards mathematics.

Instrument Development Results

The Kindergarten Mathematics Attitude Instrument (KMAI) was developed as a part of this research study in order to assess the effect of a specific kindergarten mathematics curriculum. The KMAI was synthesized from two other attitude instruments. The content was

based on the Revised Aiken-Dreger Attitude Toward Mathematics Scale (Aiken & Dreger, 1961) and the response modality was based on the Student Evaluation of Teachers Instrument (Hoak, Kleiber & Peck, 1972).

The original Aiken-Dreger Attitude Instrument was scored on two scales, enjoyment of mathematics and perceived value of mathematics. Further studies indicated mathematics to be a two factor phenomenon of enjoyment and fear (Aiken & Dreger, 1974; 1972; 1970; 1968). Factor analysis of scores on the revised instrument revealed these two factors as accounting for 62 percent of the total variance. Additional studies by Silverman (1978), Parrish (1978) and Creswell (1974) discovered three dimensions of mathematics attitudes: enjoyment, apprehension of ability and fear. These factors also accounted for the same percent of total variance (62%). Consequently, the original and revised Aiken-Dreger Attitude Toward Mathematics Scales established statistical evidence of valid constructs on either two or three scale instrument items.

The KMAI attempted to parallel the constructs previously substantiated. The items in the adapted instrument incorporated actual terminology whenever possible (e.g., happy, afraid) and consistency of words in stem construction. The KMAI did modify the language of the Revised Aiken-Dreger instrument by using appropriate words for kindergarten children (e.g., number was used rather than mathematics).

The results of a 75 student pilot study using the 24 items of the KMAI as a three factor instrument showed enjoyment and apprehensions

to be more highly correlated (.78) than fear of mathematics (.42 and .41). Factor analysis of the data did not support the three factor structure of the Revised Aiken-Dreger Attitude Instrument in this pilot study. Rather, analysis yielded two clear factors. One factor was the fear of mathematics, while the second was a combination of enjoyment and self-confidence toward mathematics. This second factor was labeled: Self-Affirmation of Mathematics. For kindergarten children, the enjoyment of mathematics seemed closely tied to the child's feelings about his/her ability to perform mathematics. The two factor structure of the KMAI was similar to the earlier research results on the Aiken-Dreger instrument which yielded two factors: enjoyment and fear of mathematics. This support provided the construct validity of the KMAI.

The construct validity of the instrument coupled with the response modality, utilizing the mailbox/trashcan format for true/false student responses, generated a reliability coefficient of $r = .94$ for self-affirmation and $r = .87$ for fear of mathematics in the pilot phase of assessment. When Cronbach Alphas were computed for each of the two scales in the final research study with 240 students, reliability coefficients yielded $r = .94$ for both factors, respectively.

One item change dealing with the child's feelings when the teacher presented mathematics was deleted from the second administration since it was frequently misinterpreted by the children and seemed to reflect feelings about the teacher rather than mathematics. A second item which read "I feel sick during number time" had the lowest total-item scale correlation within the fear scale (see Appendix I). The

word "sick" was interpreted by the children as physical illness rather than anxiety. The four longest items on both the fear and self-affirmation scale had the lowest item-total scale correlations and probably should be shortened for further administration of the KMAI (see Appendix I).

In summarizing this discussion, it should be emphasized that the pilot phase and research study supported a two factor dimension in analyzing instrument items, that reliability coefficients ultimately yielded r = .94 for both factors, and that only two relatively minor changes were necessarily incorporated into the final KMAI instrument. Analysis of the KMAI seemed to indicate it was a reliable and valid instrument for assessing affective variables related to mathematics in this study.

Conclusions

The data from the two administrations of the KMAI supported the following conclusions:

1. It is possible to reliably measure mathematics attitude of young children using the KMAI, an individually administered attitude instrument.
2. Two factors, (a) fear of mathematics and (b) self-affirmation, a factor consisting of enjoyment and self-confidence in mathematics, resulted from the analysis of the data from the KMAI in this study.

Consequently, these conclusions regarding measurement questions raised in this investigation, further substantiated the validity and reliability of the findings related to the major focus of this

experimental study. Based on the discussion of treatment results and the significant difference found between treatment and control kindergarten groups in the study, a third and final conclusion can be drawn:

3. Kindergarten children who are taught number concepts using a curriculum based on a numeration learning hierarchy have a significantly more positive attitude towards mathematics than kindergarten children who are taught number concepts using curriculum not based on a numeration learning hierarchy.

Recommendations

Several recommendations are set forth from this study.

1. Implement a research study which compares the experimental treatment in this study to another defined curriculum.
2. Control the use of manipulatives in both experimental and control groups since this appears to influence attitudes toward mathematics.
3. Conduct additional analysis of the instrument to improve redundancy of items and length of instrument.
4. Modify the instrument for use with primary-age students in small group administration.
5. Organize a systematic approach to early childhood mathematics through the structured use of self-confirming manipulatives based on a hierarchy of concepts and encourage student-determined pacing. This initial orientation to mathematics has been shown in this study to significantly influence more positive attitudes toward mathematics in young children.

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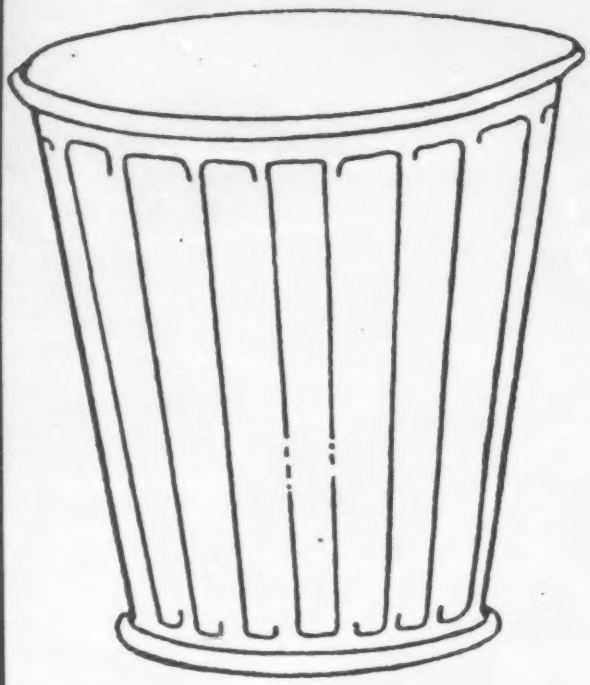
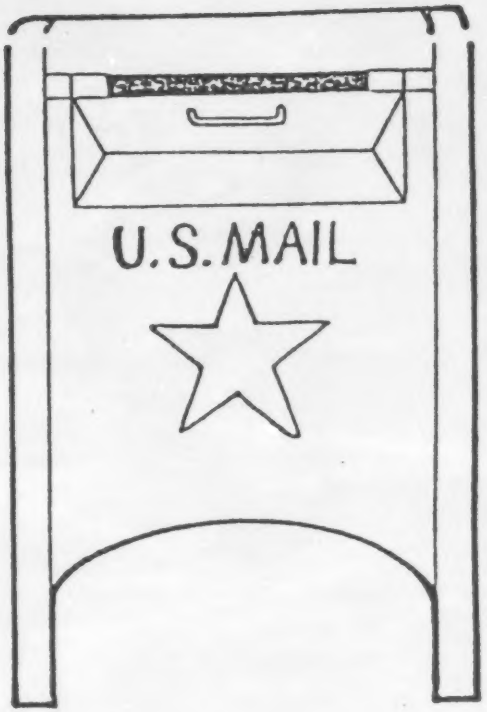
APPENDIX A

FACSIMILE OF INSTRUMENT DICHOTOMOUS RESPONSE FOLDER



(for false responses)



(for true responses)

APPENDIX B

PILOT SCORING FOR PILOT INSTRUMENT

NAME_____TEACHER_____

PILOT STUDY

KINDERGARTEN MATHEMATIC ATTITUDE INSTRUMENT

Items:	Enjoyment of Math	Apprehension of Math Ability	Fear of Math
1. I like to learn about numbers.	YES NO		
2. I can do a lot by myself with numbers.		YES NO	
3. I'm afraid of numbers.			YES NO
4. I like number time in school.	YES NO		
5. I am smart in numbers.		YES NO	
6. I get scared when its number time.			YES NO
7. I have fun with numbers.	YES NO		
8. I have good ideas in number work.		YES NO	
9. Numbers make me feel afraid.			YES NO
10. I like to work hard during number time.	YES NO		
11. I know a lot about numbers.		YES NO	
12. I think numbers are scary.			YES NO
13. I like to listen to my teacher if she/he is talking about numbers.	YES NO		
14. I can help other kids with numbers.		YES NO	
15. I'm afraid of number work.			YES NO
16. Numbers are fun for me.	YES NO		
17. I know how to do things with numbers.		YES NO	
18. I don't feel good during number time.			YES NO
19. I am happy during number time.	YES NO		
20. I'm good at numbers.		YES NO	
21. Numbers scare me.			YES NO
22. I really like numbers.	YES NO		
23. Numbers are easy for me.		YES NO	
24. I feel scared about numbers.			YES NO
TOTAL:	YES__NO__	YES__NO__	YES__NO__
Maximum Score:	8	8	8

Positive Response = 1
Negative Response = 0

APPENDIX C

SCORING FOR RESEARCH INSTRUMENT

I.D.#_____NAME:_____TEACHER:_____ EXP./AM CON. PM

SEX_____CONSER.TASK: pre__post___TEST DATA:_____

KINDERGARTEN MATHEMATIC ATTITUDE INSTRUMENT

	SELF AFFIR-MATION OF MATH	FEAR OF MATH
1. I like to learn about numbers.	YES NO	
2. I can do a lot by myself with numbers.	YES NO	
3. I'm afraid of numbers.		YES NO
4. I like number time in school.	YES NO	
5. I am smart in numbers.	YES NO	
6. I get scared when its number time.		YES NO
7. I have fun with numbers.	YES NO	
8. I have good ideas in number work.	YES NO	
9. Numbers make me feel afraid.		YES NO
10. I like to work hard during number time.	YES NO	
11. I know a lot about numbers.	YES NO	
12. I think numbers are scary.		YES NO
13. I can help other kids with numbers.	YES NO	
14. I'm afraid of number work.		YES NO
15. Numbers are fun for me.	YES NO	
16. I know how to do things with numbers.	YES NO	
17. I feel sick during number time.		YES NO
18. I am happy during number time.	YES NO	
19. I'm good at numbers.	YES NO	
20. Numbers scare me.		YES NO
21. I really like numbers.	YES NO	
22. Numbers are easy for me.	YES NO	
23. I feel scared about numbers.		YES NO
Maximum Score:	15	8

Positive Response = 1
Negative Response = 0

45

APPENDIX D

CONTROL CLASSROOM MATERIALS

Control Materials

Unifix Cubes-- plastic cubes (multiples of 10 colors). Cubes are constructed to fix together by snapping.

Table Blocks-- 3/4" hardwood blocks (multiples of 3 shapes and 4 colors).

Parquetry Blocks-- multi-colored geometric wooden shapes.

Wooden Beads-- 1/2" spheres, cubes, and cylinders in six colors.

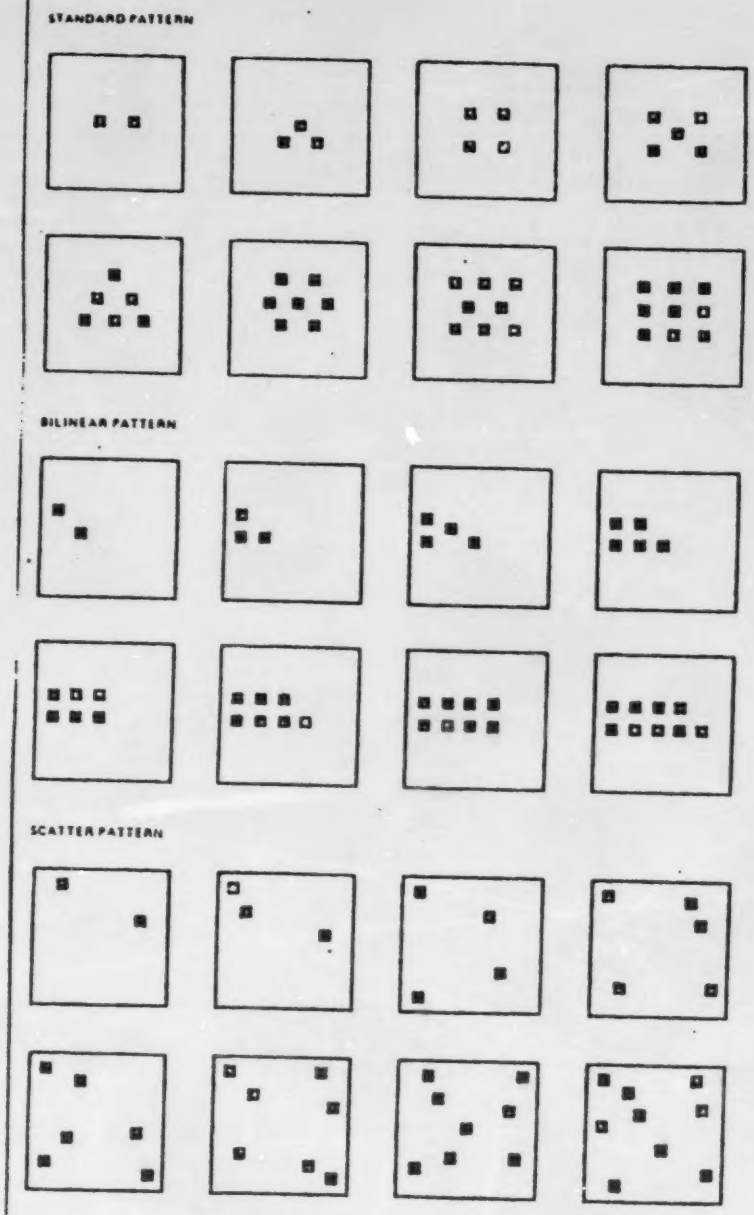
Sorting and Classifying Games-- manipulatives for matching; categorizing.

Number Puzzles and Games-- Numeral and number set match-ups; parts-to-whole pieces for construction of numeral; counting games.

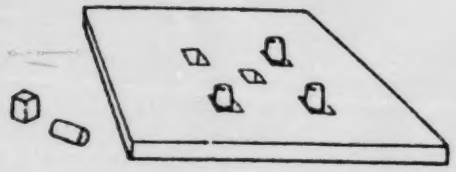
APPENDIX E

NUMBER PATTERN SET BOARDS

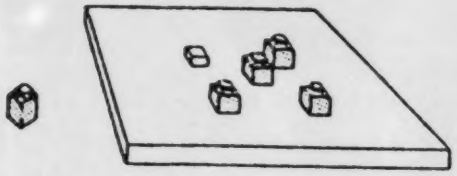
Experimental Materials



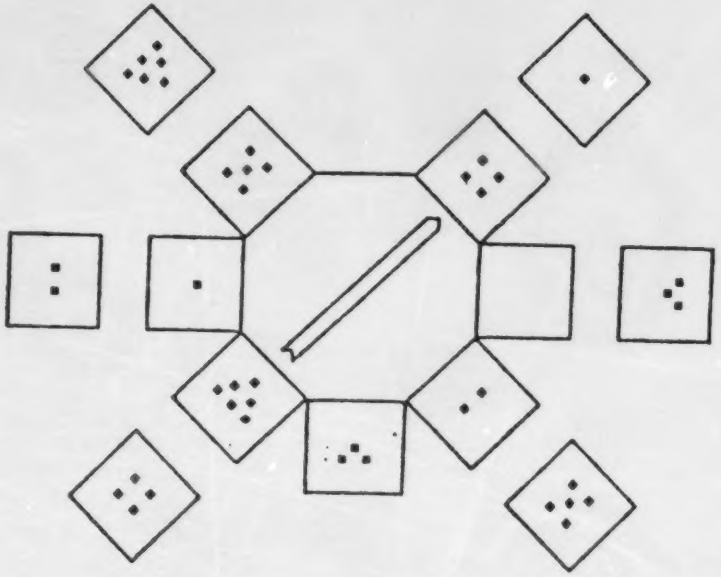
Set board for sets of 2 - 9 members.



Set board with blocks, Standard Pattern 5.



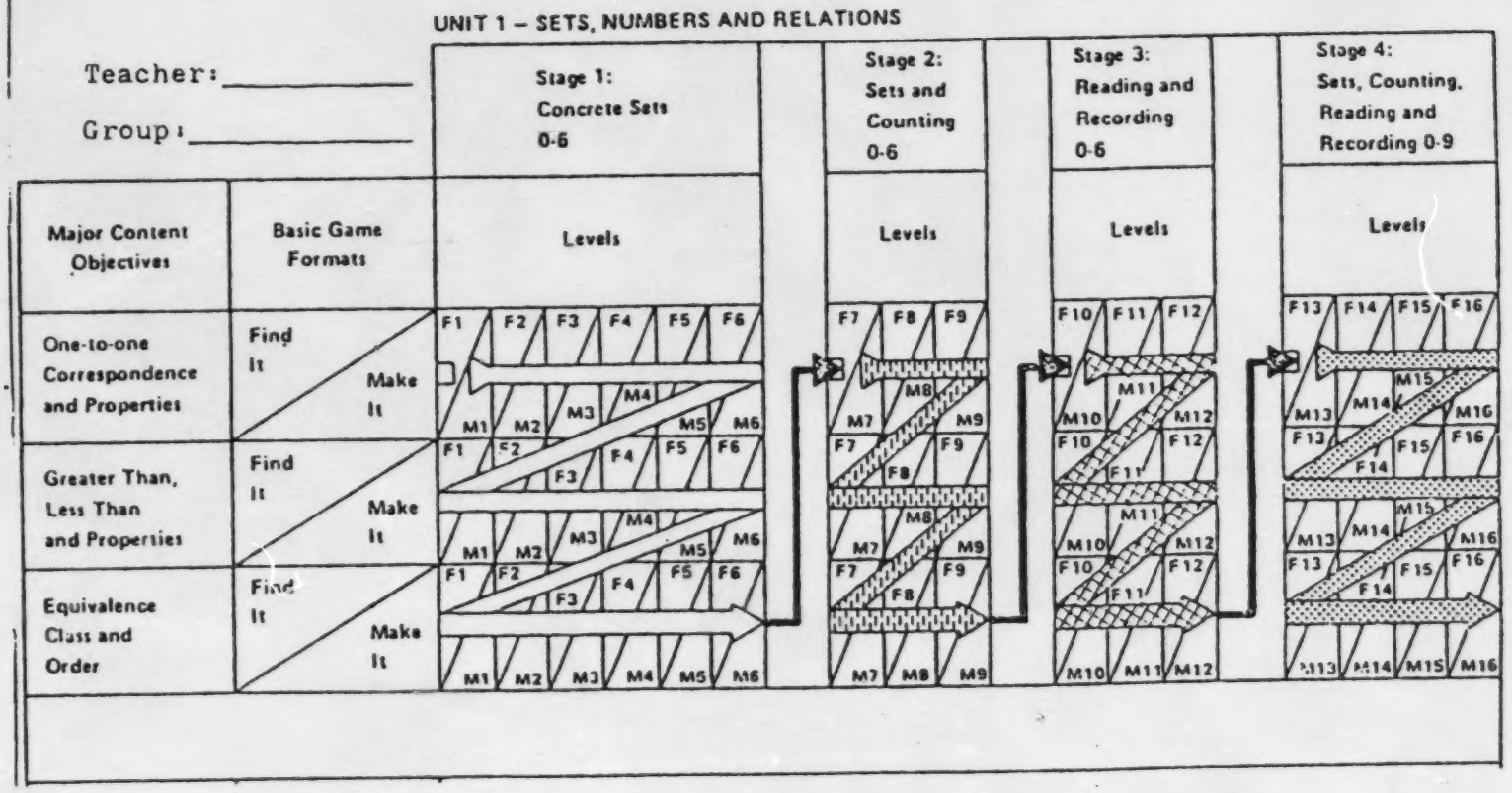
Set board with cubes, Standard Pattern 5.



Spinner cloth with sample set boards in slots.

APPENDIX F

GAME LEVEL HIERARCHY CHART FOR TEACHER RECORD KEEPING



Wilson, J.W., Uprichard,A. Fundamentals underlying number. Massachusetts: Teaching Resources Corporation, 1972.

APPENDIX G

Experimental Materials

Set Boards-- 60 plastic boards, each containing a set of 0-9 members. Set boards have been specially designed so that set configurations appear as holes on one side, raised bosses (bumps) on the reverse. Sets are arranged in three types of patterns: Standard, Bilinear, and Scatter. (see Appendix I)

Blocks-- 108 3/4" hardwood blocks (9 each of 3 shapes and 4 colors). Blocks fit easily into holse on set boards. (see Appendix I).

Unifix Cubes-- 270 plastic cubes (27 each of 10 colors). Cubes fit over raised bosses on set boards.

Numeral Caps-- 54 plastic "caps" with black numerals (6 each of 1-9), fit snugly over plastic cubes and raised bosses set boards.

Spinner Cloth-- large square of heavy vinyl. Around the outside edge of the cloth are eight slots, into each of which a set board can be placed. A spinner is mounted at the center of the spinner cloth. (see Appendix I).

Counting Set Boards-- six plastic boards, each containing nine rows of bumps/holes. Each row on the board has one more member than the previous row, beginning with one and ending with nine.

Order-Class Panel-- collapsible cardboard panels each with three vertical columns. These may be placed side by side to create a single order-class panel with nine vertical columns.

Greater Than/Less Than, Level 6

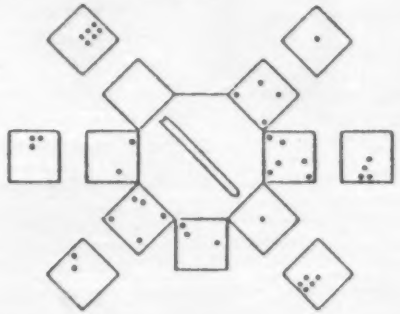
Content Objective

Greater Than and Less Than, as in Levels 1-3.

Find It — Level 6a

Materials

One set of children's set boards — Bilinear 0-6
One set of sample set boards — Scatter 0-6
Spinner cloth
Blocks in various colors and shapes



General Behavior

The child identifies a set (spatial) *greater than* or *less than* a given set (spatial).

Specific Behavior, Level 6a

The child identifies a set of holes (0-6) arranged in a bilinear pattern in his board *greater than* or *less than* (or a specific number greater than/less than) a specified set of holes arranged in a scatter pattern in a sample board.

Playing the Game and Self-Confirming Process

Same as Detailed Game Plans, for Greater Than (page 54) and Less Than (page 71).

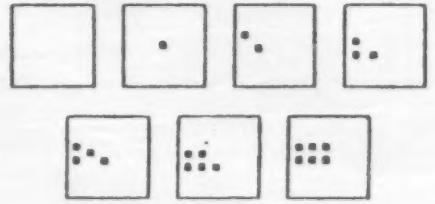
Comments

Alternate between greater than and less than.

Make It — Levels 6a and 6b

Materials

One set of sample set boards — Bilinear 1-6
One bicycle horn
One rubber gym ball
Blocks in various colors and shapes



General Behavior

The child constructs a set (spatial or non-spatial) *greater than* or *less than* a given set (spatial or non-spatial).

Specific Behaviors, Levels 6a and 6b

1. The child claps a set of sounds *greater than* or *less than* a specified set of holes (1-6) arranged in a bilinear pattern on a sample board.
2. The child creates a set of sounds on a horn *greater than* or *less than* a specified set of holes (1-6) arranged in a bilinear pattern on a sample board.
3. The child bounces a rubber gym ball a set *greater than* or *less than* a specified set of holes (1-6) arranged in a bilinear pattern on a sample board.
4. The child hops a set *greater than* or *less than* a specified set of holes (1-6) arranged in a bilinear pattern on a sample board.

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APPENDIX I

CORRECTED ITEM-TOTAL CORRELATIONS FOR SCALES

Range for Scale Corrected Item-Total Correlation
on KMAI

Self Affirmation		Fear	
	Item:		Item:
.82	(15)	.85	(14)
.80	(20)	.84	(3,9)
.79	(4,5,7)	.82	(12)
.73	(11.18)	.81	(6.23)
.68	(22)	.79	(20)
.67	(13)	.45	(17)
.66	(19)		
.65	(1)		
.55	(8)		
.54	(2)		
.53	(16)		
.46	(10)		